ROLLING STOCK

EQUIPMENT AND COMPONENTS

SUMMARY

This section deals with research activities related to the safety related performance of locomotives and railroad cars and the components and appurtenances necessary for their proper functioning, such as wheels, bearings, and brakes. The research activities include analyses, tests, evaluations, and demonstrations. Current research is expanding on that previously performed in developing and maintaining freight car standards, wheels, brakes and bearings.

The structural integrity and dynamic performance of railroad equipment and components is vital to the safety of railroad operations. Research in this area will continue to play a valuable role in developing new or revising existing regulations to continue to preserve the safety of railroad operations. Details of the targets of future research are identified below.

Advanced Braking

Technological developments make it possible to improve the braking performance of railroad cars through the use of electronic controls to activate the braking systems used in freight service. The FRA is participating in research to evaluate the feasibility and safety of proposed advanced braking systems.

RESEARCH STATUS

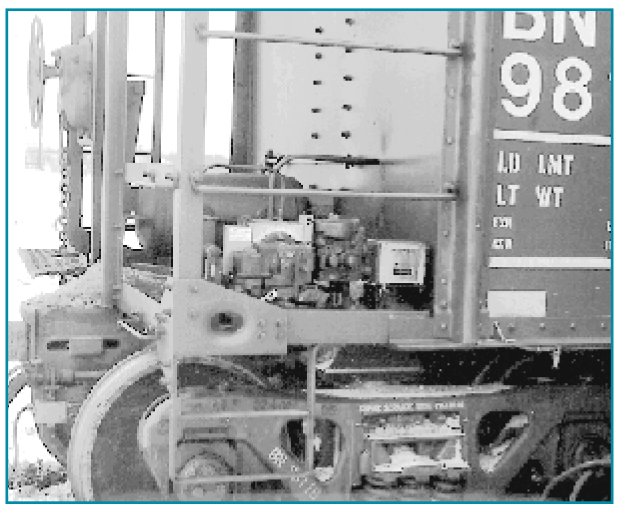
In order to overcome the limitations of conventional air brake systems, the AAR has been working on an advanced brake system study to improve the safety, performance and reliability of the braking systems used in North American freight railroad service. The ultimate goal is to develop an AAR performance specification for advanced freight brake systems used in an interchange service.

In 1995, the FRA formed a partnership with the AAR to help fund research conducted under the Electronically Controlled Pneumatic (ECP) brake program. The current draft performance requirements call for a system with the following features:

- brake pipe is used to supply air only;
- electronic control of brake cylinder pressure using a wired train line;
- graduated release;
- health monitoring of the brake system; and
- time in the signal protocol for vehicle health monitoring and distributed power.

In 1996, several tests of ECP wire line brake equipment were completed:

- fifty-car sets of ECP brake equipment were tested on the 150-car test track;
- ECP equipment was installed and tested on Conrail unit coal cars;
- ECP-equipped BNSF double stack trains completed more than 150,000 miles of service; and
- the train used in the facility for accelerated testing (FAST) at TTC was equipped with ECP brakes.



ECP Equipment on FAST Hopper

KEY FINDINGS

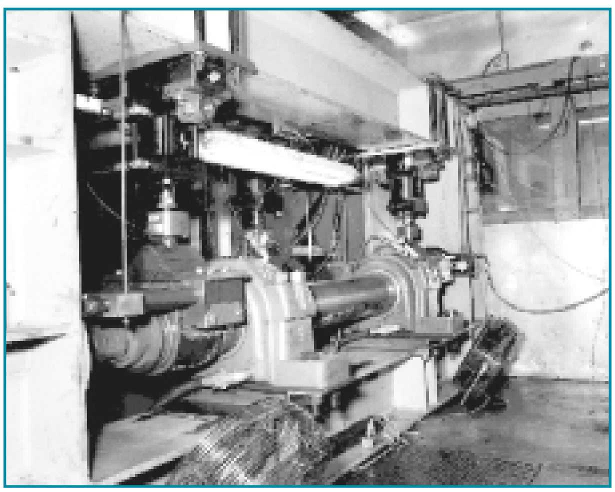
Preliminary findings indicate that ECP-equipped trains show significantly lower numbers of wheel change-outs due to brake-related defects, along with a higher consumption of brake shoes, indicating higher crew use and acceptance of the system.

FUTURE RESEARCH

Provisions for testing and evaluation of alternate approaches to ECP braking concepts, such as radio-based wireless systems, will be available. Interoperability testing to verify that candidate systems comply with the ECP specifications is currently being conducted. The FRA will continue to monitor and assist the development and deployment of novel braking system technologies.

Improved Roller Bearing Wayside Train Inspection Research

The FRA and the AAR joined forces to advance a program aimed at improving the ability of railroads to inspect roller bearings. Current infrared detection technology has proven to be inadequate as demonstrated in bearing burn-off statistics and the rate of false detection train stoppages. An improved detection system would have the ability to detect bearing failures and the type of defect at an earlier stage in the failure process.



Roller Bearing Test Rig

RESEARCH STATUS

This joint program has elicited broad industry support. Many universities, national labs, and railroad suppliers are participating in the program and are using the test data generated to develop new detection technologies and algorithms.

The program consisted of two phases, funded by the FRA and performed by the AAR. Phase I was an extensive laboratory test that generated defective and good bearing vibration and acoustic signatures used for algorithm development. Phase II consisted of a simulated revenue service test at the TTC, where acoustic data were recorded from defective and good bearings mounted on empty and loaded freight cars run past wayside microphones. The Phase II tests also encouraged potential developers to collect their own data, and several did so. The testing was successfully completed near the end of 1996. The data generated from the Phase I testing has been distributed to all participants; data from Phase II is still being reviewed. With this data, it is expected that a better detection technology could be implemented on the North American railroads in the near future, resulting in reduced operating costs and improved safety.

KEY FINDINGS

One of the major milestones of this research effort is the determination that defective bearings can be identified by their acoustic signatures. The neural network technique has been applied to distinguish the type of defect based on this signature. The wayside acoustic program demonstrated that advanced processing techniques, such as neural networks, are critical to the ability to accurately detect and classify defects. Defect recognition is influenced by the speed of the passing vehicle and the load on the bearing.

FUTURE RESEARCH

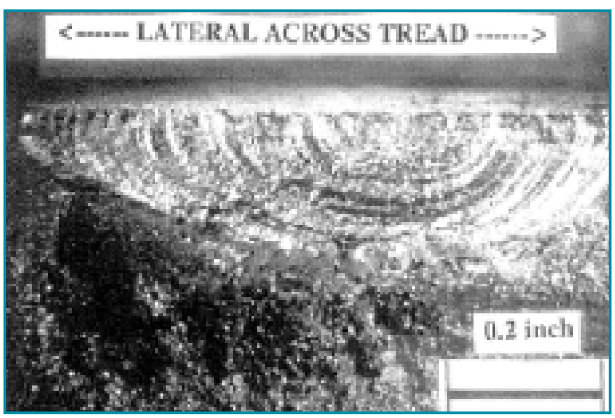
Current work is geared toward development of data to support FRA regulations permitting reinstallation of used (secondhand) bearings. Further testing will be accomplished to better educate the neural network developed by the AAR. A test plan is being developed for Phase III testing, in which participants in the research program will be given the opportunity to exercise their systems in the presence of an actual train. Testing at the TTC should begin around mid-1998 during which the prototype systems will be exposed to an operating train with various types of bearing defects.

RAILROAD WHEEL PERFORMANCE

The structural integrity of railcar wheels is vital to the safety of the traveling public. The FRA embarked upon a research program to investigate safe performance limits for wheels when, in the fall of 1991, widespread cracking was observed by FRA inspectors on several New York area commuter railroads. The FRA research program began as a preliminary investigation to determine the cause(s) of the cracking epidemic and to develop countermeasures which could be put in place quickly in order to maintain safe operations without major impact on the large number of commuters who rely on the service.

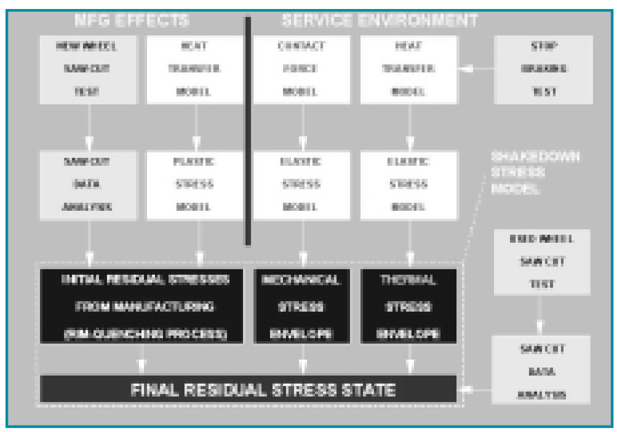
RESEARCH STATUS

The study revealed that excessive tread braking caused overheating and cracking of the wheel rim. A secondary cause was identified as concentrated wheel rim heating resulting from misaligned brake shoes which overhung the wheel rim following improper brake system maintenance. The formation of the cracks is a result of rapid heating of a shallow layer of the wheel rim. This region expands due to



the thermal effects and becomes stressed beyond the strength of the material. The accompanying photographs illustrate the observed thermal cracking which is distributed more or less uniformly around the wheel circumference. A remedial action plan was developed which permitted the affected railroads to continue operations safely.

Following the initial investigations, the FRA, with the support of the Volpe Center, developed a master plan for the assessment of commuter rail car wheels. Residual stresses, those stresses which are "locked" in a body when external loads are



removed, are a well-known cause of premature failure of structural components. The ultimate goal of the research program is to develop a method of analysis which can be pro-actively applied to estimate how service demands placed on wheels can lead to adverse residual stress in the outer rim. A schematic representation of the research plan appears above, in which the shaded portions of the program represent laboratory and field testing which was done to corroborate the analytical model development.

Stress Analysis - Safe performance limits for wheels were established as one of the targets of the research. To capture the effects of service variables on the stresses developed in railroad wheels, all contributing factors must be included:

- stresses from manufacturing processes,
- stresses developed from wheel on rail contact, and
- thermal load stresses caused by friction between the brake shoe and wheel during braking.

A product of this research has been the development of tools which represent the state-of-the-art in residual stress analysis. The software used for the wheel studies was developed by the Francis Bitter National Magnet Laboratory at the Massachusetts Institute of Technology. The software includes the ability to account for the effects of residual stresses arising from all contributors and provides a prediction of the final residual stress state in the wheel rim after multiple applications of service loads. This is the so-called "shake down state" - the point at which residual stress fluctuations have stabilized and a "semi-permanent" state of stress has been developed in the rim.

KEY FINDINGS

The manufacturing process by which railroad wheels are made involves a final heat treatment and water spray quench to induce beneficial compressive residual stresses in the rim to close, and retard further growth of, small cracks which may initiate on the tread surface. However, when wheels are placed in service and subjected to the repeated mechanical loads from wheel-on-rail contact and the thermal cycling of on-tread braking, the potential exists for high tensile stresses to develop in the material near the tread surface. These high tensile stresses may negate the residual hoop compression and result in net rim tension, a phenomenon referred to as "rim stress reversal." In this case, small cracks which form in the wheel tread will be exposed to a tensile stress field which may cause accelerated growth and could result in catastrophic wheel failure.

FUTURE RESEARCH

These effects are the subject of current FRA research aimed at the assessment of the degree of rim stress reversal as a factor in safe operating limits for wheels in commuter operation. The current goal of the program involves application of the analytical tools to estimate shake down residual stress states in wheels on electric multiple-unit trains subject to service conditions which approximate the environment on properties in the New York area, including Metro North, New Jersey Transit, and the Long Island Rail Road. The model predictions of rim residual stress will be compared with observed service defect rates (the number of wheels found to be thermally cracked).

TRAIN MAKE-UP

Studies of the relationship between train makeup and derailment safety are being conducted. It is expected that the FRA, Office of Safety will apply the results of these studies to determine the adequacy of current practice, the need for improved guidelines, and requirements for regulatory actions.

RESEARCH STATUS

Research in this area is in its developing stages. The goal of the effort is to develop data related to in-train placement of freight cars, and to determine how such placement influences derailment potential. Much work has been done by the AAR on this topic, and has been documented in a set of guidelines for good practice.

Current research seeks, as a primary goal, to investigate whether available knowledge and/or guidelines are adequate and realistic for railroad operations.

KEY FINDINGS

To date, results of this research have been limited to providing technical data to the FRA Office of Safety. Data have been collected from railroad terminals across the country that describe the train make-up of actual trains leaving major terminals. Assessment of this data is underway.

FUTURE RESEARCH

Research in this area will consist of several individual activities.

- Identify and accumulate relevant guidance material and results of previous studies related to “good practice” for train makeup and train handling. A preliminary collection of potential sources has been identified.
- Review reports of accident investigations where the cause has been identified as improper train makeup.
- Determine the relationships between actual train makeup in current railroad operations and the recommended guidelines.
- Compare current practice with the body of train makeup guidance.